# Status of Trauma Care in U.S. Army Hospitals

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**Objective: This study documents the recent trends and current state of inpatient trauma care in U.S. Army hospitals. Methods: Inpatient trauma cases from Army hospitals worldwide from October 1988 through April 2001 were analyzed. Facilities included 3 Certified Trauma Centers (CTCs), 7 non-CTC Army Medical Centers, and 42 Army Community Hospitals. Logistic regression identified mortality risk factors. Results: Overall, the Army treated 166,124 trauma cases, with a mortality rate of 0.8% (trend of 0.66% to 1.18% in fiscal years 1989–2000, $p < 0.0001$). The number of Army hospitals decreased by 44% and the number of trauma cases decreased by nearly 75%. Injury severity, patient age, hospital trauma volume, beneficiary category, hospital type, and a resource intensity measure were all significantly associated with the probability of death. Conclusions: The overall trauma mortality rate at Army hospitals during the study period was lower than that reported for civilian trauma centers. However, changes in patient profiles, increased average severity, and decreased trauma volume might have contributed to a 13% increase in mortality rates at CTCs.**

## Introduction

Downsizing of the U.S. military in the past several years has included downsizing of the Army Medical Department, in both staff and facilities. Concerns have arisen about what effects downsizing might have on inpatient trauma outcomes in Army hospitals. Trauma care is an important element of military health care, because it provides military surgeons with experience for treating battle casualties. Benchmarks are needed to measure future changes that might occur in inpatient trauma populations and outcomes. To ascertain changes that might have occurred in recent years and to set benchmarks for future reference, we analyzed existing data on inpatient trauma cases at U.S. Army hospitals.

The Army designates each of its fixed-facility hospitals as either an Army Community Hospital (ACH) or an Army Medical Center (AMC). The ACHs are staffed and equipped to provide inpatient care, diagnostic and therapeutic services in general medicine and surgery, and preventive medicine services. The AMCs are large hospitals, with the same services as ACHs, that also provide a wide range of specialized and consultative support for all medical facilities within assigned geographic areas. Three AMCs are certified trauma centers (CTCs) and function within the trauma systems of their respective states (Brooke AMC, Texas, was initially certified in December 1997 as a level I trauma center, and William Beaumont AMC, Texas, and Madigan AMC, Washington, were initially certified in September 1999 and August 2000, respectively, as level II trauma centers).

One goal of this study was to develop an explanatory mortality model. Initial models, which were presented in a detailed technical report,[1] included factors reported in the literature as predictive of inpatient trauma mortality rates, i.e., annual hospital trauma case volume, patient age, injury severity score, and hospital type. A multivariate logistic regression model using all Army trauma cases ($N$ = 166,124) found that injury severity score, age, and hospital type were significant predictors of the probability of death. In analyses restricted to severe injury cases, hospital volume was also a significant predictor.

Several studies examined effects of either hospital or trauma case volume on inpatient trauma mortality rates at trauma centers and found varied results.[2–6] Konvolinka et al.[7] found that increased volume resulted in decreased mortality rates only among patients with serious blunt injuries. Additional studies examined the influence of case volume per surgeon on trauma survival rates and came to mixed conclusions.[7–10] In the majority of those studies, however, researchers inferred that volume per surgeon was not a significant predictor of trauma mortality rates.

An important factor in any prediction of mortality rates is some measure of injury severity. We decided to use the International Classification of Diseases Injury Severity Score (ICISS).[11] ICISS was easily calculable from data in the study database, and ICISS has been reported in several articles as performing well as a predictor of trauma outcome.[11–15]

Patient age has repeatedly been shown to be a significant predictor of trauma survival rates.[16–20] Older patients have decreased chances of survival, with sharp increases in mortality rates occurring at some older age, such as 60 or 75 years.

Numerous studies have examined the effectiveness of trauma systems.[21–27] Many of those studies reported on reductions in mortality rates for seriously injured patients after establishment of regional trauma systems. Some studies that examined rural areas found no improvement in survival rates after trauma system implementation[27] or no difference in survival rates at trauma centers vs. community hospitals.[28] In this study, the hospitals involved do not form a regional trauma system but include all Army fixed-facility hospitals worldwide. The focus of these hospitals is providing care to U.S. military beneficiaries, including active duty (AD) uniformed services personnel, retired personnel, and dependents of both AD and retired personnel. Civilian emergencies and specially designated other patients form less than 10% of all trauma admissions to Army hospitals,[1] and most of these admissions are at the CTCs. (Hereafter, AD refers to U.S. uniformed services members [Army, Navy, Air

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Presented in part at the Academy for Health Services Research and Health Policy Annual Research Meeting, June 23–25, 2002, Washington, DC.

The views expressed in this article are those of the authors and do not reflect the official policy of the Department of the Army, the Department of Defense, or the U.S. government.

This manuscript was received for review in September 2003. The revised manuscript was accepted for publication in March 2004.

# Report Documentation Page

*Form Approved*
*OMB No. 0704-0188*



| | | |
|---|---|---|
| 1. REPORT DATE<br>**MAR 2004** | 2. REPORT TYPE | 3. DATES COVERED<br>**00-00-2004 to 00-00-2004** |

| | |
|---|---|
| 4. TITLE AND SUBTITLE<br>**Status of Trauma Care in U.S. Army Hospitals** | 5a. CONTRACT NUMBER<br>5b. GRANT NUMBER<br>5c. PROGRAM ELEMENT NUMBER |
| 6. AUTHOR(S) | 5d. PROJECT NUMBER<br>5e. TASK NUMBER<br>5f. WORK UNIT NUMBER |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br>**U.S. Army Institute of Surgical Research (USAISR),3400 Rawley E. Chambers Avenue,Fort Sam Houston ,TX,78234-6315** | 8. PERFORMING ORGANIZATION REPORT NUMBER |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | 10. SPONSOR/MONITOR'S ACRONYM(S)<br>11. SPONSOR/MONITOR'S REPORT NUMBER(S) |

12. DISTRIBUTION/AVAILABILITY STATEMENT
**Approved for public release; distribution unlimited**

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT<br>**unclassified** | b. ABSTRACT<br>**unclassified** | c. THIS PAGE<br>**unclassified** | **Same as Report (SAR)** | **8** | |

**Standard Form 298 (Rev. 8-98)**
Prescribed by ANSI Std Z39-18

Force, Marine Corps, Coast Guard, Public Health Service, or National Oceanographic and Atmospheric Administration] on AD status at the time of admission.)

The objective of this study was to document the recent trends and current state of inpatient trauma care in Army hospitals. In addition, we wanted to use a population-based logistic model to identify all study factors closely associated with patient outcomes.

## Methods

Data were obtained from a Department of Defense electronic database consisting of Standard Inpatient Data Records. A Standard Inpatient Data Record is generated at the end of each inpatient stay at a military hospital. For this project, we selected records meeting the following criteria: (1) the inpatient stay was at a U.S. Army fixed-facility hospital, worldwide; (2) the disposition date (date that a stay at a given military hospital ended) occurred in the period from October 1988 through April 2001; and (3) the principal diagnosis indicated trauma (International Classification of Diseases, 9th Revision, Clinical Modification, diagnosis codes 800.0–959.9). However, patients older than 60 years of age (on the date of disposition) with a principal diagnosis of isolated hip fracture (International Classification of Diseases, 9th Revision, Clinical Modification, codes 820.01–820.03, 820.09, 820.20, 820.21, 820.8, and 821.33) were excluded. Each record represents one inpatient stay at one Army hospital; patients who were transferred from one Army hospital to another were treated as separate patients (a list of abbreviations/acronyms used in this article is provided in Table I).

Variables used in data summarization and analysis included hospital type (CTC, AMC other than CTC, or ACH), hospital identifier, fiscal year (FY) of disposition (U.S. federal FY is October 1 through September 30), admission source, disposition status (dead or alive), total length of stay (LOS) (in days), intensive care unit (ICU) LOS (in days), patient age at disposition, gender, beneficiary category (criteria for a person being permitted to be treated in a military hospital), and relative weighted product (RWP) (a measure of resource intensity). A case mix index (CMI), the mean of the RWPs, was computed for each facility and hospital type for each FY. RWPs are larger for more resource-intensive cases; in general, more complicated cases are more resource intensive. A facility with a CMI of 1.0 is considered to be treating average patients.

With the methods described by Osler et al.,[11] a summary measure of trauma injury was developed. First, a survival risk ratio (SRR) was calculated for each five-digit trauma diagnosis found within the first eight diagnoses per record. An SRR is the probability of survival associated with an individual diagnosis, calculated as the number of patients with the diagnosis who survived divided by the total number of patients with that diagnosis (both numbers counted across all sites and years). A diagnosis with no associated deaths received an SRR of 1.0, whereas a diagnosis with only deaths received an SRR of 0.0.

Next, an ICISS was calculated for each patient as the product of the SRRs for trauma diagnoses found in the patient's first eight diagnosis codes. The ICISS is a summary measure of the probability of survival on the basis of the injuries received. For example, if a patient had two trauma diagnoses, with SRRs of 0.9 and 0.8, then the ICISS would be calculated as follows: ICISS = (0.9)(0.8) = 0.72. Scores were grouped into three injury severity categories, as used by Osler et al.,[11] i.e., death expected ($0 \le \text{ICISS} \le 0.25$), death undetermined ($0.25 < \text{ICISS} \le 0.5$), and death not expected ($0.5 < \text{ICISS} \le 1.0$). Throughout this article, any reference to injury severity score refers to ICISS.

Analyses throughout the study were performed with SAS version 8.2 software (SAS Institute, Cary, North Carolina). Data were summarized Army-wide and by hospital type. Overall summaries and yearly trends were examined. Univariate summary statistics were obtained for continuous variables (patient age, total LOS, ICU LOS, and ICISS), and analyses of variance were performed to determine whether significant differences occurred according to hospital type. Frequency distributions of categorical variables were obtained and $\chi^2$ analyses were performed to identify significant differences according to hospital type and FY. All reported $p$ values are two-sided, and a $p$ value of $<0.05$ was considered statistically significant.

Multiple logistic regression models for the probability of death were designed on the basis of all trauma cases Army-wide and the more severe trauma cases (ICISS of $\le 0.5$) at CTCs. Noncategorical variables available were patient age, ICISS, hospital

**TABLE I**

ABBREVIATIONS

| Abbreviation | Definition |
|---|---|
| AD | Active duty, i.e., U.S. uniformed services members (Army, Navy, Air Force, Marine Corps, Coast Guard, Public Health Service, or National Oceanographic and Atmospheric Administration) on active duty status at time of admission |
| ACH | Army Community Hospital |
| AMC | Army Medical Center |
| CMI | Case mixture index |
| CTC | Certified trauma center |
| ED | Emergency department |
| FY | Fiscal year |
| ICISS | International Classification of Diseases Injury Severity Score |
| ICU | Intensive care unit |
| LOS | Length of stay |
| OR | Odds ratio |
| RWP | Relative weighted product |
| SRR | Survival risk ratio |

trauma volume, ICU LOS, total hospital LOS, RWP, and CMI (for related hospital and FY). Categorical variables available were hospital type (ACH, AMC, or CTC), gender (male or female), beneficiary group (AD personnel and AD family members; retirees, veterans, and other dependents; or civilian emergency and other patients), admission source (direct, from the emergency department [ED]; direct, not from the ED; transfer; or other), and FY of disposition (1989–1991, 1992–1994, 1995–1997, or 1998–2001). The first value listed for each categorical variable was the reference category. To estimate relative risks of death, odds ratios (OR) were obtained.

## Results

### Overall Summaries

There were 166,124 inpatient trauma records from 50 Army hospitals during the study period. The 3 CTCs accounted for 19.5% of trauma cases, the 7 AMCs accounted for 23.0%, and the 42 ACHs accounted for 57.5%. Two hospitals changed type during the study period and were summarized under both AMCs and ACHs. However, individual trauma cases from these hospitals were summarized only under the hospital type in effect at the time of disposition.

All study variables differed significantly according to hospital type (Table II). On average, CTCs treated the oldest patients. Only 42% of trauma cases at CTCs were AD personnel and their family members, compared with 81% at AMCs and 87% at ACHs. Civilian emergency and other patients were treated at much higher rates at CTCs (32% at CTCs, compared with 3% at both AMCs and ACHs).

The complexity and resource use of trauma cases differed significantly ($p < 0.0001$) according to hospital type. Overall, trauma CMIs were 1.96 at CTCs, 1.51 at AMCs, and 1.03 at ACHs. For the entire study period, the Army had a trauma CMI of 1.32.

Overall, trauma admissions to Army hospitals demonstrated a mortality rate of 0.8%. Rates were 3.0% at CTCs, 0.5% at AMCs, and 0.2% at ACHs. Mortality rates increased nonlinearly with patient age.

Data for all years and sites contained 1,907 different trauma diagnosis codes. There were 755 diagnoses with associated deaths (SRRs ranging from 0.9997 to 0.0). Of these, 31 diagnoses had SRRs of 0.0 (i.e., all patients died; $N = 59$), consisting primarily of skull fractures, other head injuries, and third-degree burns (see the report by Wojcik et al.[1] for a full listing). The remaining 1,152 trauma diagnoses were not associated with any deaths (SRRs of 1.0). Table III presents the SRRs for the top 10 diagnoses.

Army-wide, the trauma cases had an average ICISS of 0.978. Mean severity scores and distributions of severity categories differed significantly according to hospital type ($p < 0.0001$) (Table IV). Nearly 3% of trauma cases at CTCs involved severe injuries (expected death and indeterminate categories), compared with only approximately 0.3% at AMCs and 0.2% at ACHs. Army-wide, for all years combined, the mortality rates were 79.8% for cases in which death would be expected (ICISS of $\leq 0.25$) and 0.4% for cases in which death would be unexpected (ICISS of $>0.5$) (Table V). CTCs had the highest mortality rate in each injury severity category, whereas AMCs had the lowest mortality rates for injuries where death was expected or indeterminate and ACHs had the lowest mortality rate for injuries where death was unexpected.

**TABLE II**

STUDY POPULATION

| Variables | CTC | AMC | ACH | p |
|---|---|---|---|---|
| Trauma cases, no. (%) | 32,471 (19.5) | 38,120 (23.0) | 95,533 (57.5) | |
| Mean age ± SD (years) | 32.4 ± 20.4 | 28.1 ± 17.3 | 25.6 ± 13.5 | <0.0001 |
| Age, no. (%) | | | | <0.0001 |
| 0–17 years | 6,529 (20.1) | 7,225 (19.0) | 14,738 (15.4) | |
| 18–24 years | 7,922 (24.4) | 12,396 (32.5) | 41,457 (43.4) | |
| 25–34 years | 6,157 (19.0) | 9,114 (23.9) | 22,744 (23.8) | |
| 35–44 years | 3,977 (12.2) | 4,068 (10.7) | 8,608 (9.0) | |
| 45–64 years | 4,609 (14.2) | 3,147 (8.2) | 5,856 (6.1) | |
| ≥65 years | 3,277 (10.1) | 2,170 (5.7) | 2,130 (2.2) | |
| Gender, no. (%) | | | | <0.0001 |
| Female | 8,984 (27.7) | 8,614 (22.6) | 18,840 (19.7) | |
| Male | 23,487 (72.3) | 29,506 (77.4) | 76,693 (80.3) | |
| Beneficiary category, no. (%) | | | | <0.0001 |
| AD/AD family | 13,698 (42.2) | 30,807 (80.8) | 83,245 (87.1) | |
| Retiree/veteran and other dependent | 8,392 (25.8) | 6,258 (16.4) | 9,621 (10.1) | |
| Civilian emergency and other patient | 10,381 (32.0) | 1,055 (2.8) | 2,666 (2.8) | |
| Admission source, no. (%) | | | | <0.0001 |
| Direct, from ED | 18,052 (55.6) | 13,327 (35.0) | 38,706 (40.5) | |
| Direct, not from ED | 12,236 (37.7) | 21,045 (55.2) | 53,165 (55.7) | |
| Transfer | 2,129 (6.5) | 3,683 (9.6) | 3,591 (3.7) | |
| Other | 54 (0.2) | 65 (0.2) | 71 (0.1) | |
| ICU LOS (days), mean ± SD | 0.5 ± 3.6 | 0.4 ± 2.8 | 0.1 ± 1.5 | <0.0001 |
| Total LOS (days), mean ± SD | 7.5 ± 15.1 | 7.1 ± 17.7 | 4.6 ± 9.0 | <0.0001 |
| Disposition status, no. (%) | | | | <0.0001 |
| Alive | 31,511 (97.0) | 37,922 (99.5) | 95,327 (99.8) | |
| Dead | 960 (3.0) | 198 (0.5) | 206 (0.2) | |

**TABLE III**

SRRS FOR TOP 10 INPATIENT TRAUMA DIAGNOSES ARMY-WIDE, OCTOBER 1988 TO APRIL 2001

| Diagnosis Code | Description | No. of Cases | SRR |
|---|---|---|---|
| 824.8 | Unspecified closed fracture of ankle | 5,846 | 0.9991 |
| 844.2 | Sprain of cruciate ligament of knee | 5,415 | 1.0000 |
| 836.0 | Tear of medial cartilage or meniscus of knee, current | 4,356 | 1.0000 |
| 883.2 | Open wound of fingers, with tendon involvement | 3,515 | 0.9997 |
| 813.42 | Other closed fractures of distal end of radius (alone) | 3,383 | 0.9994 |
| 854.00 | Intracranial injury of other and unspecified nature | 3,106 | 0.9891 |
| 836.1 | Tear of lateral cartilage or meniscus of knee, current | 3,053 | 0.9997 |
| 948.00 | Burn of <10% body surface with <10% or no third-degree burn | 2,894 | 0.9959 |
| 854.02 | Intracranial injury, other/not otherwise specified, with brief unconsciousness | 2,589 | 0.9996 |
| 920 | Contusion of face, scalp, and neck except eyes | 2,473 | 0.9947 |

**TABLE IV**

ICISS SUMMARY STATISTICS

| Variable | CTC | AMC | ACH | Army-wide | *p* Value |
|---|---|---|---|---|---|
| Mean ICISS ± SD[a] | 0.942 ± 0.140 | 0.983 ± 0.058 | 0.989 ± 0.44 | 0.978 ± 0.078 | <0.0001 |
| Median ICISS | 0.992 | 0.998 | 0.999 | 0.998 | |
| ICISS category, no. (%) | | | | | <0.0001 |
| Expected death | 344 (1.09) | 50 (0.13) | 61 (0.06) | 455 (0.27) | |
| Indeterminate | 588 (1.81) | 80 (0.21) | 128 (0.13) | 796 (0.48) | |
| Unexpected death | 31,539 (97.13) | 37,990 (99.66) | 95,344 (99.80) | 164,873 (99.25) | |

[a] All pairwise comparisons were significantly different.

**TABLE V**

MORTALITY RATES ACCORDING TO ICISS AND HOSPITAL TYPE

| | CTC | | AMC | | ACH | | Army-wide | |
|---|---|---|---|---|---|---|---|---|
| Severity Category | Dead/Total | % | Dead/Total | % | Dead/Total | % | Dead/Total | % |
| Expected death | 284/344 | 82.6 | 33/50 | 66.0 | 46/61 | 75.4 | 363/455 | 79.8 |
| Indeterminate | 224/588 | 38.1 | 18/80 | 22.5 | 34/128 | 26.6 | 276/796 | 34.7 |
| Unexpected death | 452/31,539 | 1.4 | 147/37,990 | 0.4 | 126/95,344 | 0.1 | 725/164,873 | 0.4 |

## Yearly Summaries (FYs)

The numbers of trauma cases and hospitals treating trauma cases decreased during the study period (Table VI). From 1989 to 2000, there was a 74.2% decrease in the number of cases and a 44.0% decrease in the number of hospitals. Each year, all hospital types treated fewer trauma cases, but the greatest

**TABLE VI**

NUMBER OF INPATIENT TRAUMA CASES AND HOSPITALS BY FY

| | CTC | | AMC | | ACH | | Army-wide | | |
|---|---|---|---|---|---|---|---|---|---|
| FY | No. | % | No. | % | No. | % | No. | % | No. of Hospitals |
| 1989 | 3,499 | 15.2 | 3,898 | 16.9 | 15,618 | 67.9 | 23,015 | 100.0 | 50 |
| 1990 | 3,607 | 15.9 | 3,675 | 16.2 | 15,430 | 67.9 | 22,712 | 100.0 | 50 |
| 1991 | 3,015 | 13.9 | 4,266 | 19.6 | 14,455 | 66.5 | 21,736 | 100.0 | 50 |
| 1992 | 3,169 | 17.2 | 4,094 | 22.2 | 11,161 | 60.6 | 18,424 | 100.0 | 50 |
| 1993 | 2,809 | 18.5 | 3,833 | 25.3 | 8,536 | 56.2 | 15,178 | 100.0 | 46 |
| 1994 | 2,721 | 19.8 | 3,713 | 27.0 | 7,316 | 53.2 | 13,750 | 100.0 | 42 |
| 1995 | 2,764 | 23.2 | 3,153 | 26.5 | 5,991 | 50.3 | 11,908 | 100.0 | 38 |
| 1996 | 2,595 | 23.9 | 2,919 | 26.9 | 5,343 | 49.2 | 10,857 | 100.0 | 37 |
| 1997 | 2,211 | 28.2 | 2,120 | 27.1 | 3,501 | 44.7 | 7,832 | 100.0 | 34 |
| 1998 | 1,858 | 29.9 | 1,812 | 29.2 | 2,542 | 40.9 | 6,212 | 100.0 | 28 |
| 1999 | 1,728 | 30.3 | 1,728 | 30.3 | 2,247 | 39.4 | 5,703 | 100.0 | 28 |
| 2000 | 1,742 | 29.3 | 1,981 | 33.3 | 2,226 | 37.4 | 5,949 | 100.0 | 28 |
| 2001[a] | 753 | 26.4 | 928 | 32.6 | 1,167 | 41.0 | 2,848 | 100.0 | 28 |
| Total | 32,471 | | 38,120 | | 95,533 | | 166,124 | | |

[a] Data are for 7 months (October 2000 to April 2001).

change occurred in ACHs, which showed an 85.7% decrease from 1989 to 2000. In comparison, trauma cases decreased by 50.2% at CTCs and by 49.2% at AMCs. During the same period, total Army inpatient volume (trauma and nontrauma) decreased by 68.3%, from 420,186 cases in 1989 to 132,992 cases in 2000.[1] In 1989, trauma accounted for 5.5% of total inpatient dispositions (23,015 of 420,186 cases); by 2000, it accounted for only 4.5% (5,949 of 132,992 cases).

During the study period, there was a change in trauma patient profiles. Fewer AD personnel and their families were seen in later years (83.3% in 1989 and 65.9% in 2000). An opposite trend was noted for retirees, veterans, and other dependents, who represented 11.9% of all trauma cases in 1989 and 17.3% of trauma cases in 2000. The percentage of other patients and civilian emergencies more than tripled between 1989 and 2000 (4.9% vs. 16.8%). Examination of the beneficiary profiles for the three CTCs combined showed that major changes occurred in some of the beneficiary groups during the study period (Fig. 1). In 1989, AD personnel and their families represented 55.6% of trauma cases at CTCs. By 2000, they accounted for only 23.2%. In contrast, civilian emergencies and other patients represented 18.8% of CTC trauma cases in 1989 but had increased to 50.7% in 2000.

The average ICU LOS for trauma cases increased during the study period, especially at the CTCs. The average ICU LOS at CTCs ranged from a low of 0.1 days in 1989 to approximately 1.5 days in 2000.

In contrast, total hospital stays got shorter. Overall, the mean total LOS for trauma cases decreased from 6.8 days in 1989 to 4.6 days in 2000. The LOS at CTCs decreased from a high of 9.3 days in 1989 to a low of 6.0 days in 1997 and then increased to a mean of 7.3 days in 2000. The mean total LOS at AMCs peaked at 9.7 days in 1990 and then decreased to 3.7 days in 2000. The LOS at ACHs decreased from a mean of 5.6 days in 1989 to 3.2 days in 2000.

From 1989 to 2000, CTCs had a 26% increase in the trauma CMI, in contrast to AMCs, which had an 18% decrease; the trauma CMI at ACHs was fairly stable, with only a 5% increase. The average resource intensity per trauma case for all Army sites during these years increased 20%.

Throughout the study period, the average yearly ICISS remained at approximately 0.99 for ACHs and 0.98 for AMCs. For CTCs, the average ICISS was approximately 0.95 from 1989 through 1996 but decreased slightly in 1997 and thereafter remained at 0.93. Distribution of the three ICISS categories varied significantly, both Army-wide ($p < 0.0001$) and within each hospital type ($p < 0.0001$ for each hospital type). Army-wide, the percentage of trauma cases in the expected-death category was generally higher after 1996, compared with levels observed in 1989–1991.

Mantel-Haenszel $\chi^2$ analysis found that patient disposition status differed significantly according to hospital type, after controlling for FY ($p < 0.0001$) (Fig. 2). Analysis showed that higher mortality rates for CTCs during 1997–1999 reflected

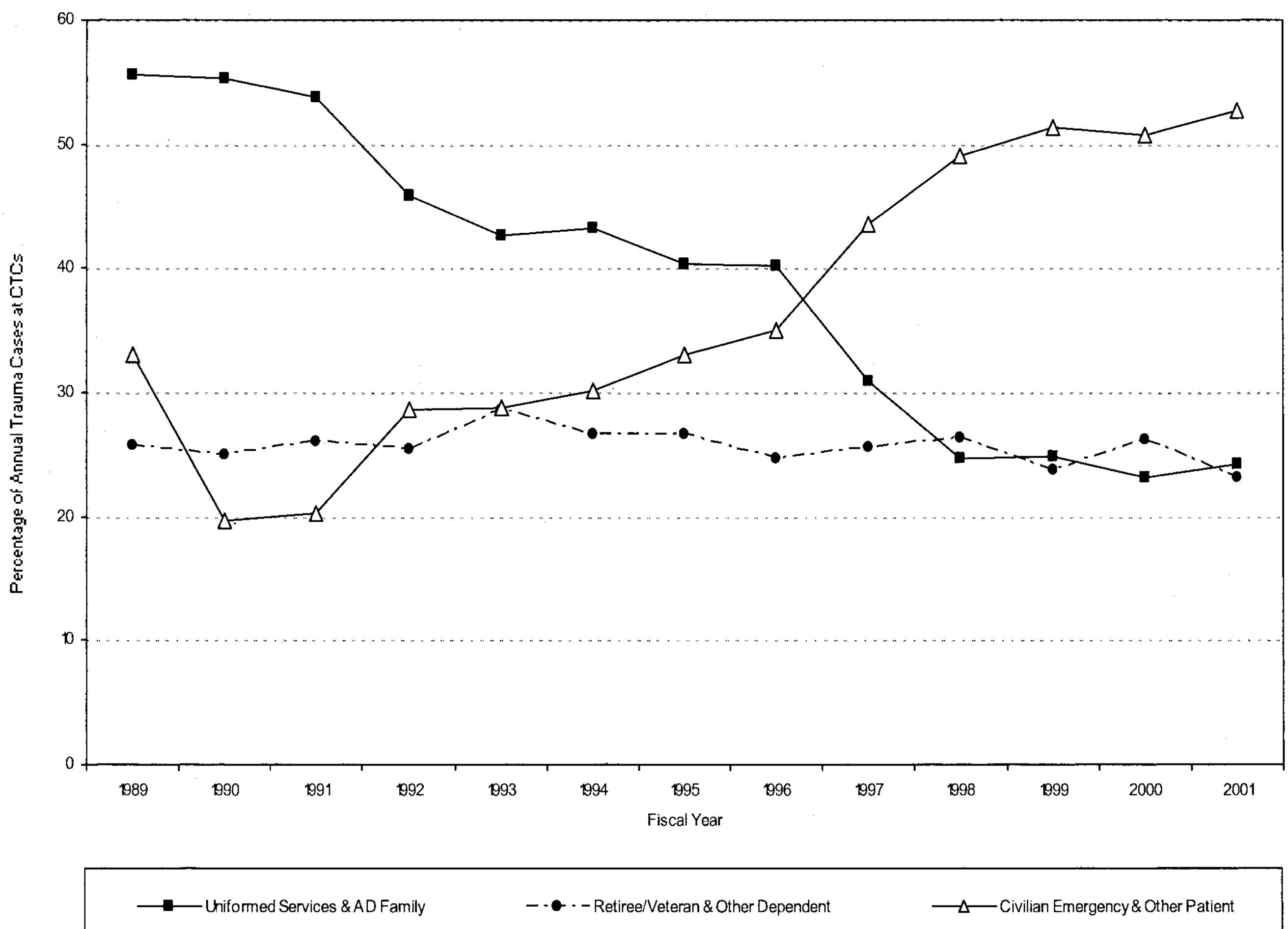


**Fig. 1. Distribution of inpatient trauma cases at Army CTCs according to beneficiary groups (October 1988 to April 2001).**

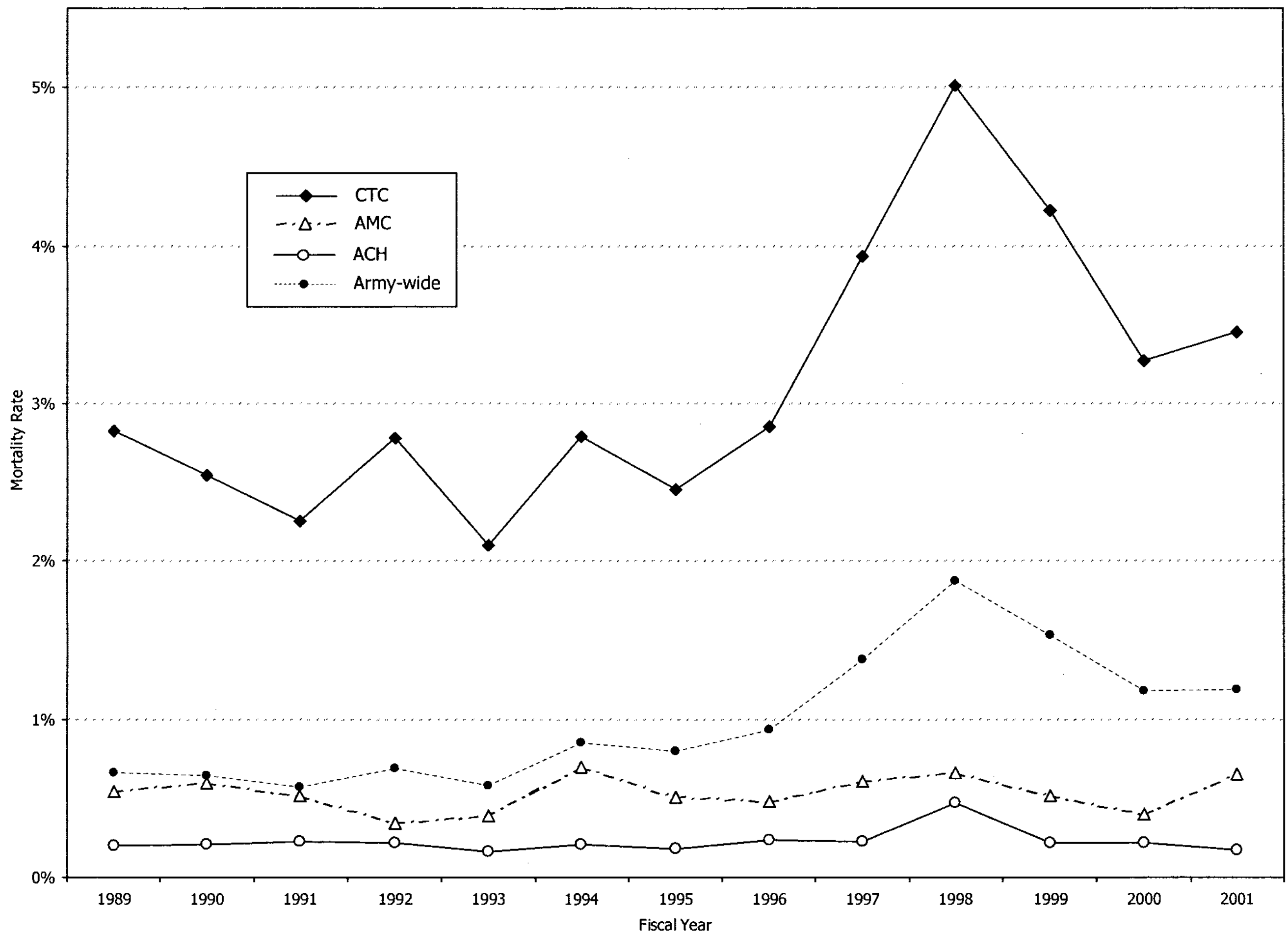


Fig. 2. Mortality rates for inpatient trauma patients at U.S. Army hospitals according to hospital type and FY of disposition (October 1988 to April 2001).

higher mortality rates at all three CTCs. We postulated that only certain beneficiary groups might be responsible for these higher rates. Analyses indicated that mortality rates remained low for AD personnel and their families throughout the study period. The high mortality rates shown for CTCs for 1997–1999 were attributable primarily to patients in the civilian emergency and other patient group and, to a lesser extent, to retirees, veterans, and other dependents.

Total Army mortality rates demonstrated an upward trend for the study period (from 0.6% in 1989 to 1.18% in 2000, $p < 0.0001$), mainly because of increased mortality rates at CTCs (from 2.83% in 1989 to 3.27% in 2000). No change in mortality rates occurred for AMCs ($p = 0.7438$) and ACHs ($p = 0.6254$).

### Logistic Regression Analysis

The overall model, using all trauma cases ($N = 166{,}124$), found that ICISS, age, total LOS, ICU LOS, hospital trauma volume, RWP, hospital type, beneficiary category, and admission source were significantly associated with the probability of death (Table VII). No significant association was found for gender. Also, not including the FY time period resulted in a better model. On the basis of the area under the receiver operator characteristic curve ($c = 0.960$), the selected model had good predictive capabilities. Compared with ACHs, the odds of death were 1.5 times greater at CTCs and 1.7 times greater at AMCs. Compared with AD personnel and their families, the odds of death were 2.4 times greater for retirees, veterans, and other dependents and 3.3 times greater for civilian emergency and other patients. A 1-unit increase in the RWP was associated with a 16% increase in the predicted odds of death. To obtain a usable OR, the ICISS was also modeled with 0.05-unit categories. The odds of death decreased approximately 36% for every 0.05-unit increase in ICISS (OR = 0.637).

In analyses restricted to more severe injury cases at CTCs (ICISS of ≤0.5, $N = 864$), the best model was obtained by omitting the high-mortality rate 1998 data. ICISS, age, trauma volume, total LOS, RWP, beneficiary group, and admission source were significantly associated with death ($c = 0.925$) (Table VIII). For every 1-unit increase in RWP, the odds of dying increased by 18%; for every 0.05-unit increase in ICISS, the odds of dying decreased by 30% (OR = 0.704). Compared with AD personnel and their families, the odds of dying were 3.7 times greater for retirees, veterans, and other dependents and 3.2 times greater for civilian emergency and other patients. Odds of dying for direct non-ED admissions were 2.3 times greater than for direct ED admissions.

## Discussion

During 1989–2001, there were 166,124 cases from 50 Army hospitals. Nearly 20% of these cases were treated at the three

TABLE VII

LOGISTIC REGRESSION ANALYSIS OF TRAUMA OUTCOMES ($N$ = 166,124), OVERALL MODEL

| Predictor Variable | Coefficient Estimate | $p$ | Estimated OR | 95% Confidence Interval |
|---|---|---|---|---|
| Intercept | 0.7888 | <0.0001 | | |
| ICISS | −9.0080 | <0.0001 | <0.001 | <0.001 to <0.001 |
| Age | 0.0374 | <0.0001 | 1.038 | 1.034–1.042 |
| No. of dispositions | 0.0003 | 0.0045 | 1.000 | 1.000–1.001 |
| Total LOS | −0.0736 | <0.0001 | 0.929 | 0.921–0.937 |
| ICU LOS | 0.0290 | <0.0001 | 1.029 | 1.018–1.041 |
| RWP | 0.1498 | <0.0001 | 1.162 | 1.137–1.187 |
| ACH (ref) | | | 1.0 | |
| AMC | 0.5440 | <0.0001 | 1.723 | 1.359–2.185 |
| CTC | 0.4296 | 0.0011 | 1.537 | 1.188–1.988 |
| AD/AD family (ref) | | | 1.0 | |
| Retiree/veteran and other dependent | 0.8652 | <0.0001 | 2.376 | 1.839–3.069 |
| Civilian emergency and other patient | 1.1948 | <0.0001 | 3.303 | 2.600–4.196 |
| Direct, from ED (ref) | | | 1.0 | |
| Direct, not from ED | −0.2046 | 0.0173 | 0.815 | 0.689–0.964 |
| Other admission | −0.2831 | 0.0805 | 0.753 | 0.549–1.035 |

[a] Ref, Reference category.

TABLE VIII

LOGISTIC REGRESSION ANALYSIS OF TRAUMA OUTCOMES ($N$ = 864), SUBSET MODEL (ICISS OF ≤0.5 AT CTCS, 1998 DATA EXCLUDED

| Predictor Variable | Coefficient Estimate | $p$ | Estimated OR | 95% Confidence Interval |
|---|---|---|---|---|
| Intercept | 0.0824 | 0.8820 | | |
| ICISS | −7.0140 | <0.0001 | <0.001 | <0.001–0.004 |
| Age | 0.0275 | <0.0001 | 1.028 | 1.016–1.040 |
| No. of dispositions | 0.0006 | 0.0368 | 1.001 | 1.000–1.001 |
| Total LOS | −0.1077 | <0.0001 | 0.898 | 0.880–0.916 |
| RWP | 0.1674 | <0.0001 | 1.182 | 1.128–1.239 |
| AD/AD family (ref) | | | 1.0 | |
| Retiree/veteran and other dependent | 1.3057 | 0.0116 | 3.690 | 1.339–10.169 |
| Civilian emergency and other patient | 1.1719 | 0.0023 | 3.228 | 1.519–6.861 |
| Direct, from ED (ref) | | | 1.0 | |
| Direct, not from ED | 0.8313 | 0.0040 | 2.296 | 1.303–4.046 |
| Other admission | 0.3209 | 0.4426 | 1.378 | 0.608–3.127 |

[a] Ref, Reference category.

CTCs. This study provides compelling evidence that trauma care at Army hospitals involved different patient populations at the three hospital types. Nearly all (97%) trauma admissions to AMCs and ACHs were military-related. However, 87% of ACH trauma admissions were AD personnel and their families (compared with 81% at AMCs), resulting in a younger, more male-dominated, patient population. CTCs treated the fewest military-related trauma patients. Nearly one-third of CTC cases involved civilian emergency and other patients, and the percentage of such patients was much greater in recent years (51%) than in 1989, when they represented only 19% of CTC trauma cases. On average, CTC patients were older, probably because of the higher percentage of retirees, veterans, and other dependents (26%). From the logistic model based on all trauma cases, we found that the factors with the greatest associated risks of death were the two beneficiary groups primarily treated at CTCs, i.e., civilian emergency and other patients and retirees, veterans, and other dependents. Beneficiary group was more influential in death outcomes than was hospital type. Any future analysis or planning concerning inpatient trauma care at U.S. Army hospitals will need to account for differences in patient profiles among the three types of facilities.

The overall trauma mortality rate at Army hospitals during the study period (0.8%, 1,364 of 166,124 cases) was lower than rates reported in the literature for several trauma populations, for which overall inpatient trauma mortality rates ranged from 2% to 8%.[7,12,13,16,19,28] Subgroup (hospital type and ICISS category) comparisons could be made with results reported by Rogers et al.,[28] who performed a population-based analysis of trauma care in Vermont (a rural state with no formal trauma system). As in our study, trauma centers had higher mortality rates overall, reflecting a lower average ICISS (Army CTCs: 3.0% mortality rate, mean ICISS = 0.94; Vermont trauma centers: 3.1% mortality rate, mean ICISS = 0.94; Army ACHs: 0.2% mortality rate, mean ICISS = 0.99; Vermont community hospitals: 1.8% mortality rate, mean ICISS = 0.97). The two hospital systems differed more when comparisons were made of mortality rates according to hospital type and ICISS category. For expected-death, indeterminate-death, and unexpected-death categories, mortality rates were 82.6%, 38.1%, and 1.4%, respectively, at Army CTCs, compared with 68.3%, 46.3%, and 2.1% at Vermont trauma centers; rates were 75.4%, 26.6%, and

0.1% at Army ACHs, compared with 94.1%, 73.3%, and 1.5% at Vermont community hospitals. In the Army, regardless of injury severity, mortality rates were highest at trauma centers. In Vermont, mortality rates for major trauma cases (ICISS of ≤0.5) were higher at community hospitals and those for less severely injured patients were higher at trauma centers.

As in several previous studies,[13,15,19,28] injury severity proved to be a powerful predictor of outcomes. We examined a variety of models not included in this article, and ICISS was the best single variable in explaining patient outcomes ($c = 0.934$).

In our study, the majority of trauma diagnoses for which the patient always died were head injuries and burns. Similar findings were obtained by Osler et al.,[11] who reported that the majority of the most lethal trauma diagnosis codes from the North Carolina Hospital Discharge Registry for 1990–1995 represented head injuries, burns, and arterial injuries. Rutledge et al.[12] found that injuries with the highest mortality rates were severe central nervous system injuries.

The results of this study showed that inpatient trauma care in Army hospitals decreased significantly during the study period (almost 75% decrease in trauma cases and 44% decrease in hospitals). Overall, the trauma mortality rate at Army hospitals was lower than rates reported for civilian trauma centers, but CTCs demonstrated a 13% increase in the mortality rate. We think that the increased CTC mortality rate might be primarily associated with changes in population profiles (more civilian emergencies and fewer AD personnel cases) and an increase in injury severity (lower average ICISS). The Army-wide decrease in trauma volume also might have contributed to the increase in the CTC mortality rate. Any further decrease in trauma volume should be a subject of concern. Besides reducing medical staff experience in treating battle-type injuries, further reductions in trauma care at CTCs may reduce trauma volumes to levels below the minimum required for trauma center certification.

We recommend Army-wide trauma registry implementation, to enable better measurement of trauma care at each hospital and to record the additional information usually entered into trauma registry databases. We recommend close monitoring of selected population-based outcomes (such as mortality rate, LOS, and average ICISS), to ensure timely responses to any shortcomings that may occur. Trauma care in Army hospitals remains a solid part of the Health Care Protection program and its measures.

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